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A proposal of design education assistance system with design process visualization reflecting competitive evaluation

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Abstract

Global warming has been raised as a key issue recently. The carbon emission is considerably affected by the energy consumption of daily life among plenty of causes, and the need of changing people's behavior formed a consensus for reducing the energy consumption. Because people's lifestyle can be affected by those who create the built environment to a great extent, designers' awareness about sustainable lifestyle facilitates people's behavior change into sustainable one. The basic assumption is that, if some information insinuating eco-friendly design is provided in an ambient way to the designers during the design education, the awareness about sustainable design can be significantly improved. In this paper, we identify the effects on the design process when the eco-friendly design information is provided to students together with visual information of comparative evaluation. A game theory-based scenario was utilized to stimulate the competitive design activities among students. We propose a design education assistance system that reflects the outcomes of the experiment. In conclusion, providing the competitive evaluation comparison with ambient information about sustainable design helps develop the design awareness on sustainability with better outputs.

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Keywords: design process; design education; visualization system; competitive evaluation; Education Assistance System

1. Background

Global warming caused by carbon emissions has become a key issue, and is considerably affected by the energy consumption of daily life (Bin & Dowlatabadi 2005, Wei *et al.* 2007). In order to reduce the energy

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consumption it is necessary to change the people's behavior (Pierce *et al.* 2008, Makonin *et al.* 2012). The lifestyle is inherent to some extent, but most parts are formed by the interactions with environment (Thaler & Sunstein 2008). The probability is high that the surrounding environments are generally created by architect and urban planners. Changing environment where people live is more influential to environment issues caused by the carbon from buildings and cities. This environment is generally built by designers who plan the buildings and cities. So, it is important to change the designer's awareness into sustainable one. Since providing specific information through visualization is effective to the recognizing about information and changes in people's awareness (Holmes 2007), the various information of eco-friendly design and urban conditions are provided continuously in an ambient way to the designers during the design education for increasing the awareness about sustainability. Therefore designers can be induced to make future cities and buildings sustainable.

2. Research Objective

Architectural design is a process of deriving the design solution through the physical and cognitive stages that resolves multiple design requirements and constraints. The design process is characterized by designer's individual peculiarities (Gough 1981) but a significant portion can be affected by learning and teaching (Akin 1996, Oxman 2001). In particular, there are various interactions between the designer's cognitive behavior and acquired information on the process for solving the design problems (Kim & Kim 2007). Thus, acquisition of information during the course of the designing carries a lot of clout. The architecture students learn the knowledge of designing through the professor's lectures or acquire the data for oneself from the precedents with similar conditions. In this paper, we experiment on educational approaches about the effective delivery of information that induce the students to make sustainable design outputs. We identify the effects on the design output, when eco-friendly design information is provided to students with visual information of competitive evaluation of other student's design. In addition we propose a design education assistance system that competitive evaluation and ambient information helped to improve the sustainability of student's design outputs through the visualization of design processes integrated with the competitive evaluation.

3. Research Method

A pilot study was conducted to achieve the purpose of the research that the ambient information is influence on awareness changing and then reflection on the design output. Participants were limited to 4 or 5 graders of the Department of Architecture in order to confirm the design outputs within short time. We had given a house design problem of different site-condition everyday of three-day experiment. Each site has a relatively small area(about 80m^2, 127m^2, 135m^2) comparing the number of family(a family of 6 or 7, and 3families). And the design problems emphasize the natural light which is generally regarded as important and is one of the environmental elements(Figure 1).

Fig. 1. Site conditions: The building codes are followed in the codes of Seoul in Korea. There is limitation on the building height (about 10m).

Eight students were divided four teams. Each team was consisted of two students and designed during two hours per a day. The design outputs was assessed and scored, and the evaluation result was notified to each team before the next experiment. Process and the outputs of the design were recorded by the video, image and voice for the evaluation. Each team worked in separate room, so couldn't check the contents of other teams. Teams were divided into two groups by providing information about environmentally friendly building. And they were subdivided according to the specific conditions. This grouping creates 'competitive-only atmosphere' or 'competitive and cooperative atmosphere' which requires more time to exchange information with other team members(Figure 2).

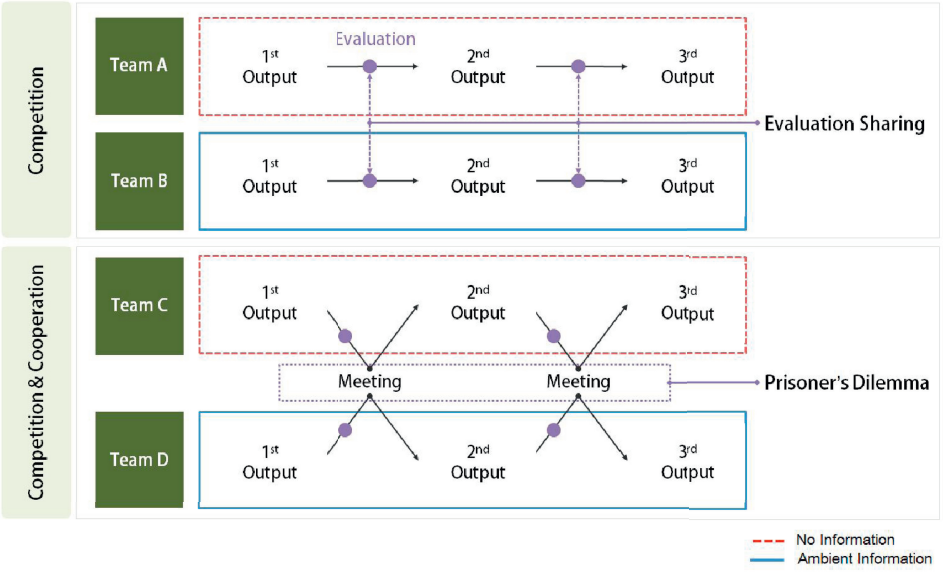

Fig. 2. Design experiment process

Figure 3 is the provided design data example about environmentally friendly buildings. In the experiment, the way of providing the ambient information was not fully arranged due to the time limit. So, the information of eco-friendly building such as nature friendly materials, natural lighting and ventilation, energy-saving systems, water circulation systems and planting of building was randomly attached on the worktable to make students respond quickly. And this situation about providing the information was not announced to students.

Fig. 3. Providing of ambient information

To encourage participation of the experiment, students get into competition with others. The evaluation of each team's design output was differently offered like figure 4 along the competitive environment. The evaluation in competition condition was presented both own score (bar graph) and other team's score (line graph) by factors. On the other hand, the teams that are provided meeting times (in competition and cooperation condition) were offered own score (bar graph) by factors and the opposing team's total score (dot on bar graph).

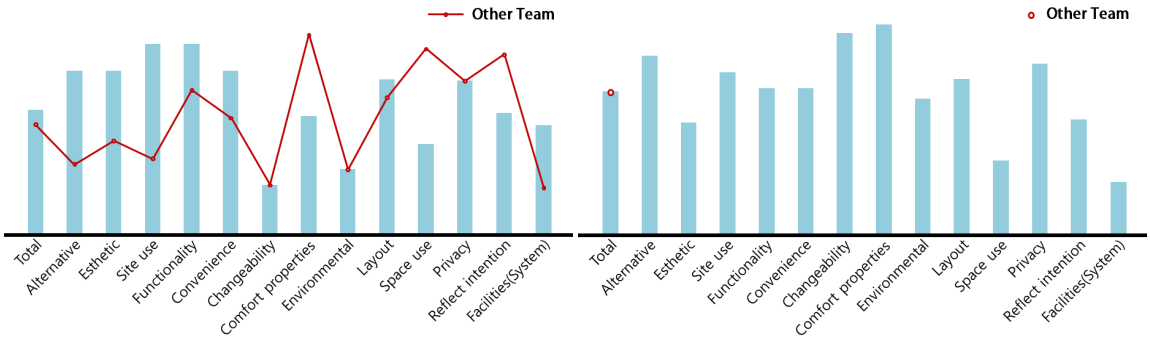

Fig. 4. Example of evaluation graph about 2nd day's outputs; competition team(left), competition & cooperation team(right)

In the meeting time, each team exchanges opinions with others on the design considerations in previous design operation. That moment, interchange of idea applied prisoner's dilemma, the game theory, for preventing design standardization resulted from share of every data (Table 1). Each team gets the score of 1 point when both of them contain the same element in the design, 2 points when one team contains any elements but the other team doesn't contain, and 0 point when neither of them contain the elements. Applying the game theory, it is possible that students have own unique design elements and strategically share the design information.

Table 1. Way for scoring applying of prisoner's dilemma

	Inclusion	Exclusion
Inclusion	1, 1	2, 0
Exclusion	0, 2	0, 0

4. Experiment Analysis

The recording files were used to trace the design process of students. In this performance, the way of gathering and utilizing the ambient information and the effect on the design outputs of the acquired information was tried to be verified. And the effect of the competitive and cooperative relations between the teams was verified too. Referring the voice and video recording files, students' thinking and practice were investigated using the dialogue between the team members during the process for drawing the design outputs. Among four teams, the design process of team D (competitive and cooperative condition) was chosen for the first analysis (Figure 5).

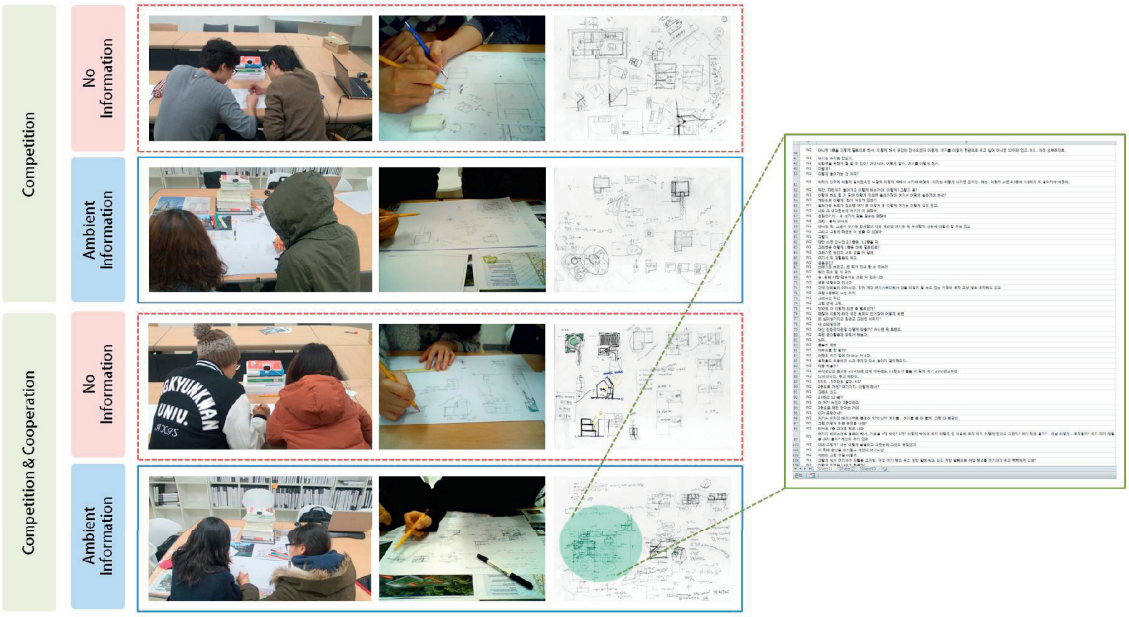

Fig. 5. Appearance of students conducting an experiment and design outputs and dialogue sample of team D

First of all, students decided the type of rooms by floors and draw up the programs. At this time, each room was composed efficiently by substantial consideration about the sunshine and view that are required by dwellers. There was a feature that reflects the factors pointed out from the other team at the meeting time before the design experiment, when students laid out the plans. The opposing team comments that the children's room was planned to be best in contradistinction to other family's rooms. So, one student took up the position that other family's rooms plan to be better too. Similarly, students introduced the elements again that high scored at the evaluation from tutor. As the practical space-use got the high score on the evaluation, students introduced the same element used on the first day to prevent the creation of dead-spaces (Figure 6).

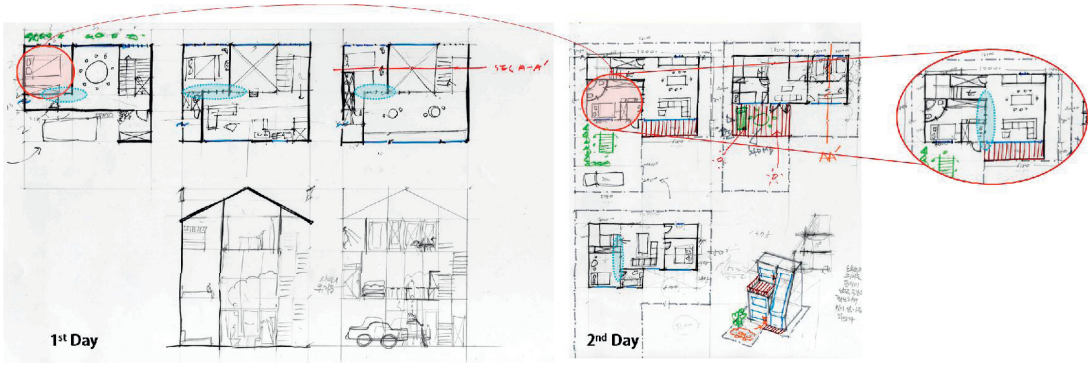

Fig. 6. Movement of rooms toward south(red line) and application of a sliding door(blue dotted line)

In the process of floor planning step, the furniture arrangement was discussed. The students tried to apply the unique furniture which had seen before to save the space. At this time, one student found the similar case with their design in the attached pictures on the worktable. Then, they reconsidered and canceled the idea of special furniture. Instead, they decided to compose the space and arrange the furniture following the example on the table (Figure 7),

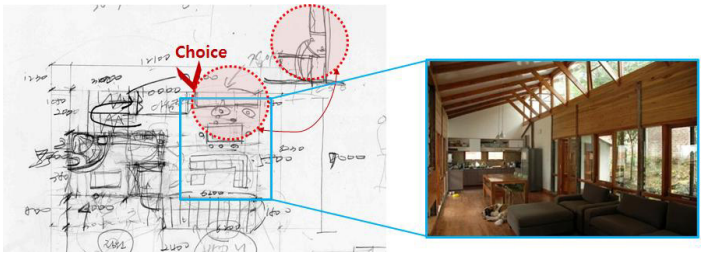

Fig. 7. Two alternatives and reflection of ambient information

On the other hand, the design process of team A (no ambient information, no meeting time) was affected by visible evaluation graph with other team. These students tend to be more concerned for evaluation result than students of team that could have meeting time for exchanging the opinions. They looked into the evaluation graph and check the low scored elements again and again before and after experiment (Figure 8).

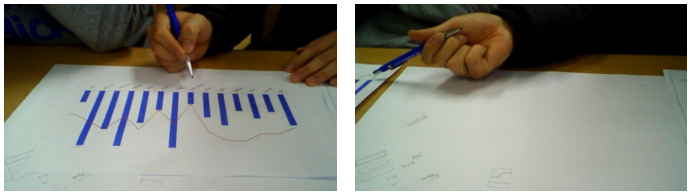

Fig. 8. Checking evaluation graph before and after experiment

In a case of team A, they got poorer ratings on the domain of alternatives, aesthetic, and facility than team B. So in opposition to general space assignment widthwise for a family, they suggested the spatial division lengthwise (Figure 9: left). Students decided that an alternative is more profitable to all dwellers and more effective in using space than first design, so they choose the alternative as a final form. And the mass of building had the unique bumpy exterior, didn't shape like a box at earlier experiment (Figure 9: right). The requisite of facility was mentioned on the drawing board. However, students didn't cover the facilities on the design due to lack of knowledge about facilities system and pressure of the restricted hours.

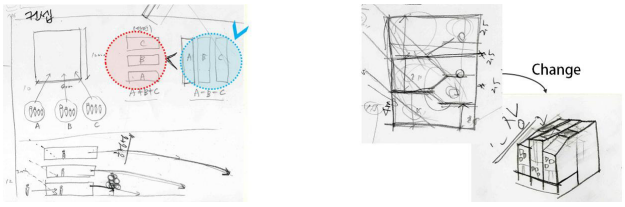

Fig. 9. Creating alternative(left) and changing of the building mass(right)

Through this experiment, it is proved that students are affected by ambient visible information, visible evaluation from tutor and exchange of opinion with other students in the design process. Especially, the competitive spirit goes a long way towards developing the design. The greater diversity of design objects are created when the students in competitive condition that is combined with cooperation condition. The system which is reflected the result of experiment is enabled to provide effective design education. That system increases the student's awareness about sustainability as strengthen the competition through the ambient information, visualization of design process and output's evaluation among the students. Therefore, it would help build future cities or buildings that formed salubrious environment where citizens live, if the education assistance system is developed.

5. Proposal of the Education Assistance System

As the design processes can be generally visualized like figure 10 (upper) (Kim 2006), it is have the merit of effectiveness for design tutor to confirm and guide the design operations of many students easily. So that they manage design studios and assess the students. Design object is offered as various alternatives along the designer's cognition or restriction on design problem and continually repeated the processes that combine or eliminate the design elements along the tutor's evaluation. The objects are turned up as a final one last. At first time, the design objects begin as conceptual design such as simple sketches or bubble diagrams and finally become an architectural design plan or three-dimensional object. Figure10 (lower) is visualized team D's design outputs of 2nd day in the same way (Figure 10: upper).

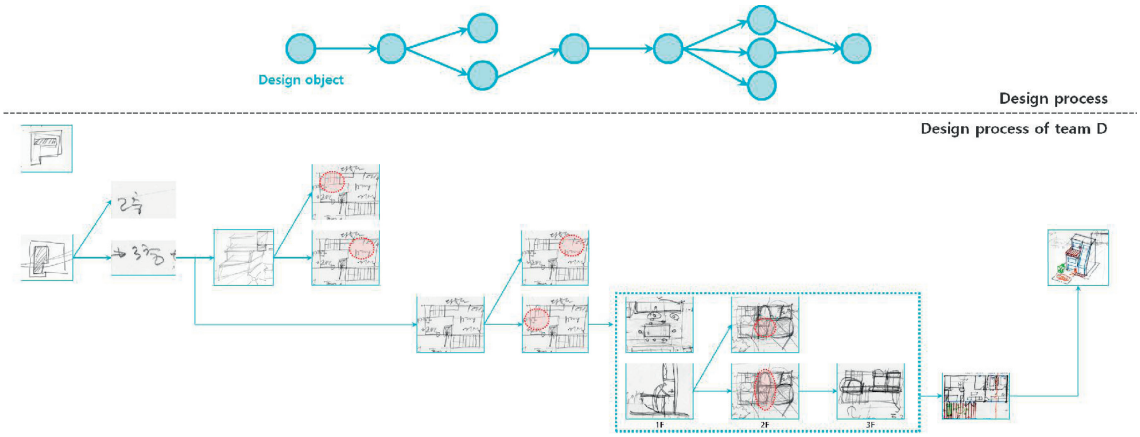

Fig. 10. The example of design process visualization(upper) and visualization of team D's design process(lower)

When the students develop their design, by the experiment and theories, the acquired knowledge and provided information excessively influence the designs. And if the delivery of provided information is interactive, the effect can be maximized. In this paper, we reflect the results of the previous experiment, so organized the visualization system that provide the needed information for design with the evaluation of design outputs to the students on the design process like figure 11. The students received the design problem and then analyzed and comprehended the design requirements or constraints. And the student's design outputs are advanced by the

ambient information provided constantly and intended to develop the design quality through comparing evaluation with other students during design process.

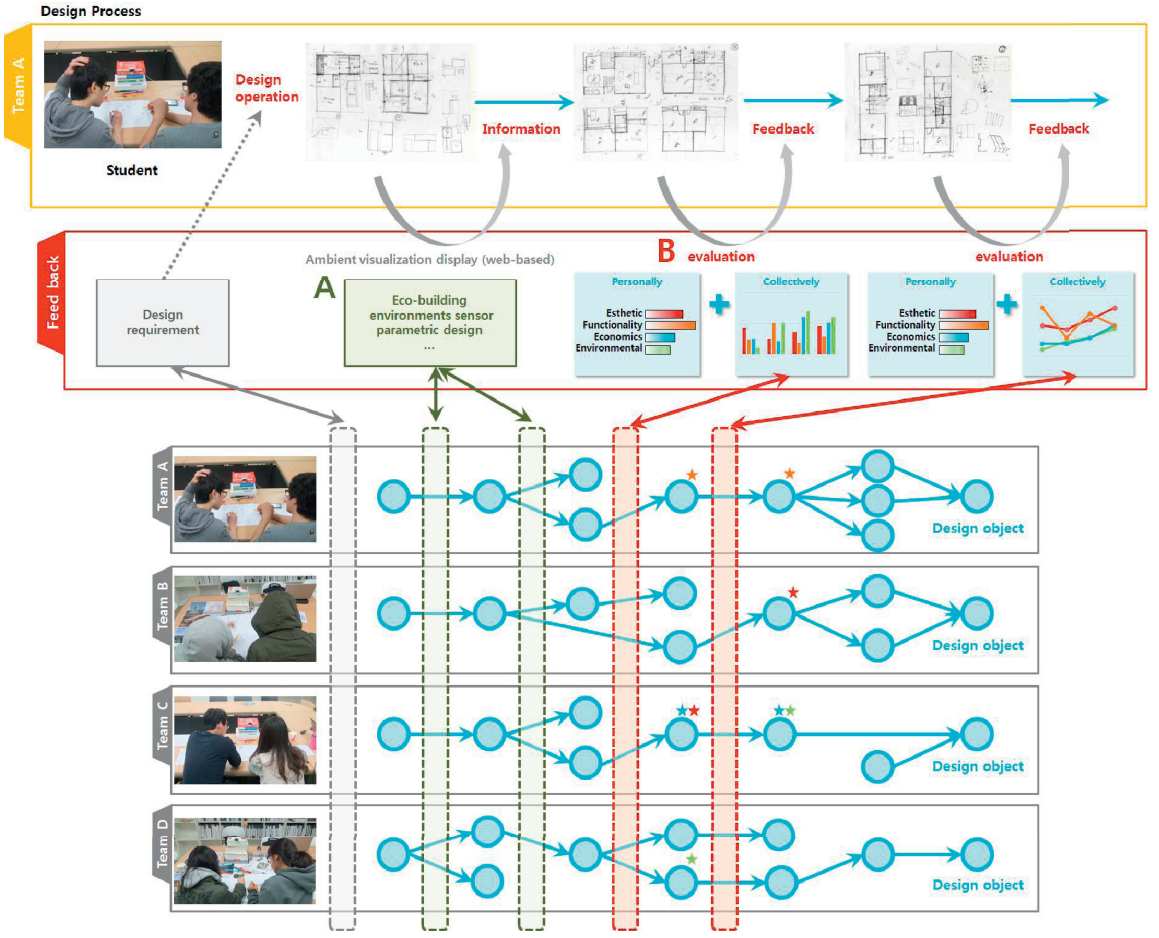

Fig. 11. Example of design process visualization integrated with providing information and competitive evaluation

- A : Provide the sustainable design information continuously by installing the monitor on the corridor where many students moved or in the design studio. Students with smartphone get more detailed data like a system plan using the QRcode that linked web data. In additionally, if the screen or the sculpture that visualize the indoor environmental information such as air pollution and then some for design is served additionally to student, it is possible to raise awareness about environment of students.

- B : Provide the professor's evaluation that based on sketched alternative designs that inputted into system for final result. And that is evaluated each design's element such as aesthetics, functionality and so on. The evaluation is shared with other students, thus enhance the cognition of competition among the students. The

repetitive evaluation of design object using the system is enabling to expect to improve quality of student's design output.

6. Conclusion

This study aims for students to have environmental awareness naturally and improve quality of the design through information visualization of eco-friendly design and output evaluation to architecture student in process of learning the knowledge for design. To achieve this purpose, we use the way that visualize the eco-system designs' examples for student to increase understanding and reflecting acquired knowledge about sustainability from theoretical lecture. Also, providing the competitive and comparative evaluation with strategic information exchange among the students via game theory helps increase the students' awareness about sustainability more. Finally, when the students become the professional designers, the nature friendly practices and knowledge that have been formed from this educational system are naturally reflected in the design of cities or buildings. Then, the urban and residential environment is built salubrious and comfortable for people. Furthermore, the lifestyles of people living in this type of cities or buildings will be maintained in more sustainable ways.

Acknowledgements

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